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Analysis of Wastes Height Reduction, Macrobiology And Microbiology Colony (*Fecal coli*) on Dry Leaves Composting Process

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Abstract: The scattered leaf wastes can be turned into high nutrition organic fertilizer by utilizing vermicomposting methods. The wastes will be consumed by earthworms reducing the mass of the waste and the excrement can be used as vermicompost. One of the important things regarding the potential of earthworms in vermicomposting is the consumption rate or the decrease in the waste pile heights. Also, the number of microorganism colonies can be determined using the MPN (Most Probable Number) method based on the parameters of fecal coli bacteria in SNI 19-7030-2004. The vermicompost produced in this study comes from banyan leaves (*Ficus benjamina*) and bamboo leaves (*Bambusa bambos*). It takes 56 days for the vermicompost to ripen. The decrease in pile heights was measured every three days using a ruler and resulted in an average reduction of 2.18 cm/day for Ficus benjamina leaves and 1.0 cm/day for Bambusa bamboos leaves. Samples of microorganisms were taken on the 28th and 56th day and the MPN value was calculated. The MPN value obtained on the 28th day was 290 MPN/g and on the 56th day was 460 MPN/g, indicating that the colony had reached the predetermined quality standard.

Keywords: Fecal coli, Macroorganism, Organic waste, Vermicompost

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INTRODUCTION

Leaf wastes have the potential to be the source of nutrients used in agriculture. Leaf wastes decomposition can fertilize the soil and provide nutrients for plants. This can be accomplished by deliberately composting the wastes (Dominguez & Edwards, 2004). However, the conventional composting process is taking too long. The microorganisms involved are thermophilic, only active at a high temperature around 45-65°C (Dominguez & Edwards, 1997). However, there is an alternative, such as using the vermicomposting method.

Vermicomposting is the decomposition of organic matter that involves cooperation between earthworms and microorganisms. Earthworms will emit large amounts of cast, which will be difficult to separate between the substrate and the organic material, affecting the rate of decline (Domínguez *et al.*, 2010). There are several microorganisms that have a role vermicomposting process, mostly bacteria, fungi, and actinomycetes (Dominguez & Edwards, 1997).

There are two factors that influence the waste reduction process which are macroorganisms and microorganisms. Macroorganism consists of earthworms, ants, termites, and others. Earthworms play a major role in reducing the waste volume, as the worms use the wastes as a food source. The degradation caused by the worms is also assisted by microorganisms through casting (feces from worms). Bacteria play a major role in this casting process (Lazcano *et al.*, 2008). Microorganisms also play an important role, by breaking down organic materials into compost which is rich in both macro and micro-nutrients that are needed by plants (Yurmiati & Hidayati, 2008).

Different type of worm has different waste decomposition capabilities, the types of worms that are often used are *Lumbricus rubellus* and *Eisenia foetida*. In this study, a different type of worm, the jasmine worms were used. Although its capability is still unknown, it is thought to have similar characteristics with the worm from the Eudrilus eugeniae species. According to Khwairakpam & Bhargava (2010), the amount of Fecal coli found in vermicompost produced by Eudrilus eugeniae was 4.36 log MPN / g. Therefore, a test to determine the decrease in the level of decomposition produced by these worms was carried out, and then the result was compared with the product produced by both *Lumbricus rubellus* and *Eisenia foetida* worms.

METHOD

The research was conducted at the Faculty of Civil Engineering and Planning, Islamic University of Indonesia from September 2016 to January 2017. Analysis of compost from dry leaves was carried out at the Environmental Biotechnology Laboratory, Islamic University of Indonesia.

The culture medium consists of leaf waste and starter from previously produced compost. The experimental containers in this study were made from used goods such as waste tires and iron rods which were tied in such a way using rope and given a cavity for air circulation with a diameter of 45 cm, a height of 105 cm, and a volume of 0.17 m^3.

There are two things that will be observed in this study, first is the rate of decline, and the second is the amount of *Fecal coli*, in MPN/gr adjusted to SNI. In addition, because the reactor will be a breeding ground for various types of macroorganisms, the macroorganisms will be identified.

The rate of decline or rate of decomposition is obtained from measuring the decline in the waste pile heights every three days during the composting period. Measurements are taken using a ruler or other measuring instrument. The leaf wastes will be added twice, first using leaves from the banyan tree *(Ficus benjamina)*, and the second using bamboo leaves *(Bambusa bambos)*.

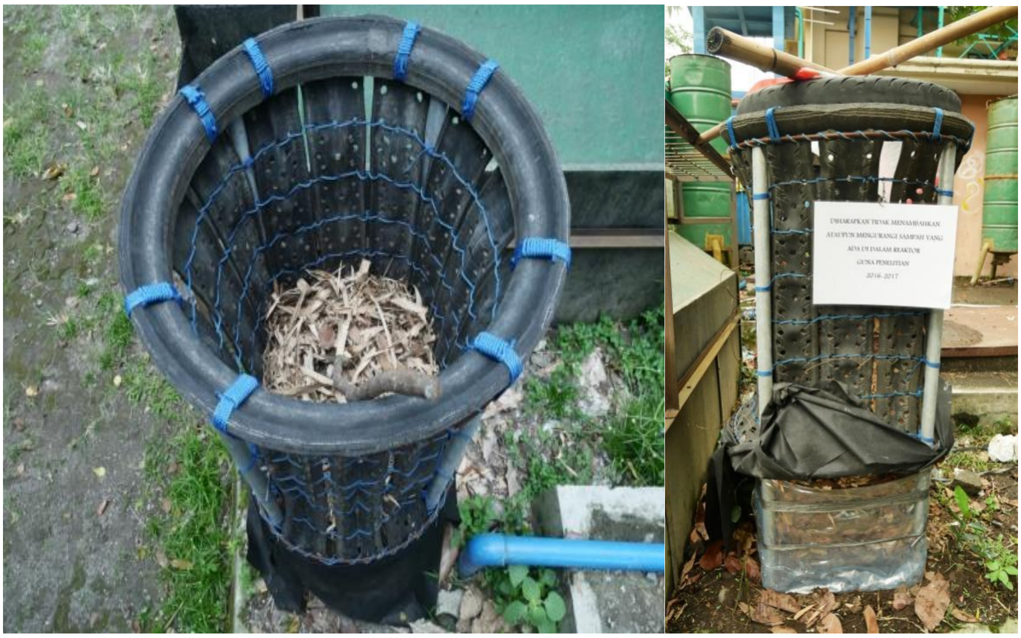


Figure 1. Vermicompost reactor

The samples then tested at the laboratory every two weeks starting from the 28th day. Laboratory tests were carried out to determine the amount of MPN/gr of *Fecal coli* in the compost. The MPN test is divided into two stages, first is the Presumptive Test by diluting samples on LB (Lactose Broth) media into 3 dilutions, 10^{-1}, 10^{-2}, and 10^{-3}. For the 10-1 and 10-2 dilutions, single lactose will be used and for the 10-3 dilutions double lactose will be used. The second stage is the Confirmative Test by septically moving as much as 1 Ose from each tube that forms gas on LB (Lactose Broth) media into a tube containing 10 ml of *Brilliant Green Lactose Bile* (BGLB) and then the BGLB tube is labeled according to the inserted solutions. All tubes were then incubated at 37°C for 24 - 48 hours.

RESULTS AND DISCUSSION

Leaf Waste Decrease Rate

The rate of decline was observed in order to determine how quickly the earthworm decomposes the waste.

Table 1. The rate of decline on the first addition

Num.	Days	Height (cm)	Decrease (cm)
On the first addition the initial height is 73 cm			
1	1	66	7
2	4	63	3
3	7	53	10
4	10	46	7
5	13	41	5
6	16	38	3

Sum	35
Average	2,18

The results of the observations in Table 1. indicate that on the first addition using banyan leaves, the consumption rates are high, with an average reduction value of 2.18 cm/day. The highest consumption rate was found on the 7th day, around 10 cm, this was due to the decomposition by the worms on the banyan leaves used.

Table 2. The rate of decline on the second addition

Num.	Days	Height (cm)	Decrease (cm)
	On the first addition the initial height is 73 cm		
1	19	60	4
2	22	57	3
3	25	54	3
4	28	51	3
5	31	49	2
6	34	47	2
7	37	45	2
8	40	42	3
9	43	39	3
10	46	36	3
11	49	33	3
12	52	30	3
13	56	27	3
	Sum		37
	Average		1,0

Based on Table 2. The lowest consumption rate can be seen when the bamboo leaves were applied, which was around 1.0 cm/day, this was caused by the low nutrients contained in bamboo leaves resulted in decrease in earthworm consumption rates.

In vermicomposting, earthworms will consume the leaves and the microorganism will help in the decomposition process, resulted in casting, casting contains various organic materials full of nutrients needed by plants such as nitrogen, phosphorus, minerals, and vitamins (Simanungkalit et al., 2006).

In this research, other species of worms besides *Lumbricus rubellus* were used, this was done in order to determine the capability of other worms species in vermicomposting. The rate of reduction was measured once every three days and differentiated for each addition of waste due to differences in the leaves used. Based on the results, it can be concluded that in the first leaves' addition, the rate of decline is higher, this could be caused by the type of leaf used, which is the leaves of the banyan tree.

The rates of reduction were compared to determine the capabilities of the species of earthworms used in research with the species of earthworms commonly used in vermicomposting, *Lumbricus rubellus*, and *Eisena foetida*. The comparison can be seen in Table 3.

Table 3. Comparison of decomposition efficiency between the earthworm species

Num.	Earthworm Species	Decomposition Efficiency (%) Average/week
1	*E. foetida*	28,90
2	*L. rubellus*	27,93
3	Jasmine Worms	18,79

The decomposition efficiency of *E. foetida* and *L. rubellus* worms shows values of 28.90% and 27.93%, respectively. On jasmine worms, only 18.79% or around half of the capability of commonly used vermicompost earthworms. However, despite its low reduction efficiency value, this worm can still be used for vermicomposting with the aim of helping to reduce dry leaf waste or other organic waste in the surrounding environment.

Identification of *Fecal coli*

The laboratory tests were conducted in order to obtain the MPN (Most Probable Number) value of the *Fecal coli* colony inside the resulted compost. The test is done using the Duplo technique. The test used Lactose Broth (LB) media at the Presumptive Test stage and Brilliant Green Lactose Broth (BGLB) at the Confirmation Test stage.

Table 4. *Fecal colis*' MPN results

Num	Sample	Date	Presumptive Test			Confirmation Test			MPN (MPN/gr)
			10	1	0,1	10	1	0,1	
			gr						
Day-28									
1	Compost	21-Nov-16	3	3	3	3	2	3	290
2	Compost	21-Nov-16	3	3	3	3	2	3	290
Day-56									
3	Compost	19-Des-16	3	3	3	3	3	1	460
4	Compost	19-Des-16	3	3	3	3	3	1	460

Based on the test results, it can be seen that the MPN value on the 28th day was 290 MPN/gr, and on the 56th, when the compost was qualified as ripe, the value was around 460 MPN/gr. Using the standards set by SNI: 19-7030-2004, the amount of Fecal coli MPN that is deemed good for compost is not more than 1000 MPN/gr. The test result shows that the MPN content in the vermicompost samples is below the predetermined standards. If the MPN value is higher than the standard, the C:N ratio will decrease due to the excessive utilization of carbon and nitrogen elements. Organic materials such as carbon and nitrogen are utilized by microbes to synthesize proteins used to build cell walls and microbial structures (Lin, 2014).

Identifying Macroorganisms

The macroorganisms in the reactor were identified visually, by digging the compost pile by hand, then collecting the macroorganisms according to their types. The most dominant macroorganisms in the compost media were the colonies of the Asian Needle Ants (*Pachycondyla chinensis*) and the Asian Subterranean Termite of *Coptotermes gestroi* species.

Identification and role of African crawler earthworm / Eudrilus eugeniae

The earthworms used in this study have physical characteristics similar to those of Eudrilus Eugeniae. This earthworm is characterized by a reddish-brown color, a cylindrical shape, and a metametrically segmented type. The average weight and length of each individual are around 3-4 grams and 12.5 cm. This earthworm can grow well in temperatures of 25°C - 30°C and will reach its maximum weight and length in 15 to 20 weeks. The number of segments in this worm varies, ranging from 80 to more than 100 with the clitellum between the 13-20 segments. Eudrilus Eugeniae has a potential role in vermicomposting (Vijaya, 2012).

Name : *African Nightcrawler / Eudrilus Eugeniae*

Kindomg	**:**	*Animalia*
Phylum	**:**	*Annelida*
Class	**:**	*Clitellata*
Order	**:**	*Haplotaxida*
Family	**:**	*Eudrilidae*
Genus	**:**	*Eudrilus*

Figure 2. Species of earthworms used

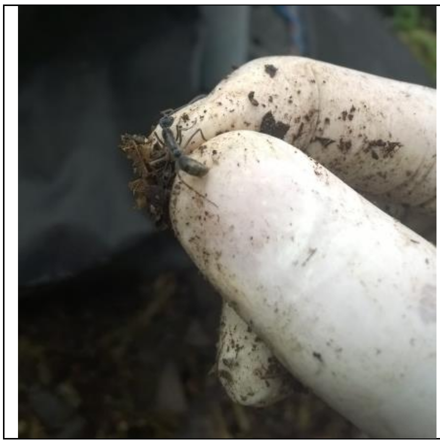
Earthworms play an important role in breaking down carbon, it is also affected the soil composition and participates in the degradation of cellulose, and caused an increase in humus. The intestines in earthworms contain large amounts of microorganisms, enzymes, and hormones that will help decompose organic matter into vermicompost (Pathma & Sakthivel, 2012).

Identification and role of the asian needle ant

Asian needle ants are a type of ant that lives in moderate climates, these ants can be found in forests, plantation soils, as well as in urban areas.

Asian needle ants usually make their nests in forested soil, fallen and rotting tree limbs, or in piles of leaves. Some of these ant colonies also live in termite nests in the soil (Rodriguez et al., 2012).

Asian Needle Ants have a black color. The body size of worker ants is about 3.4 to 5.0 mm in length, while the size of the queen ant is much larger at about 5.0 - 6.0 mm. Worker ants in this colony do not have wings, whereas queens and males have wings, although queen ants lose their wings after the mating process. This ant has a large petiole, a pair of fairly large eyes, a stinger, and a long head (Gown, 2009).



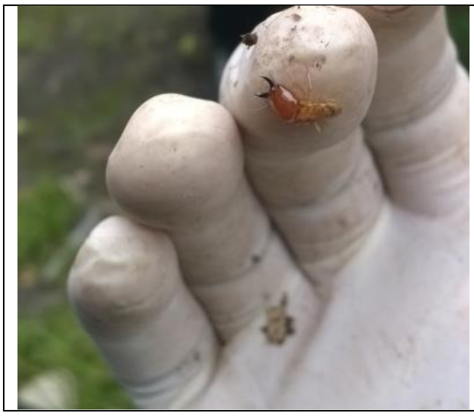
Name	**:**	*Asian Needle Ant*
Kingdom	**:**	*Animalia*
Phylum	**:**	*Arthropoda*
Class	**:**	*Insecta*
Order	**:**	*Hymenoptera*
Family	**:**	*Formicidae*
Genus	**:**	*Pachycondyla*
Spesies	**:**	*P. chinensis*

Gambar 3. Jenis semut yang terdapat dalam reaktor.

The existence of the ants in the soil not only affects the soil environment but also has an impact on the activity and abundance of other soil biotas, such as soil microorganisms (fungi, bacteria, actinomycetes), nematodes, and soil insects (Blomqvist et al., 2000). The soil around the ants' mound has better chemical parameters than the control plots (ordinary soil used as a comparison), specifically an increase in organic content of P and K^+ as well as the pH (H_2O) and C:N ratio in the mound. Meanwhile, the mound that used to be ant nests, experienced an increase in the content of C and N (Dostal et al., 2004).

Identification and role of the asian subterranean termite

The Asian Underground Termite is endemic to Southeast Asia. These termites built their nest using a special material called carton. The size of the nest can reach a very large size that can accommodate hundreds of thousands of termites in one colony. This type of termite can nest on the soil surface if humidity levels are high (Su, 2006).



Nama	:	*Asian Subterranean Termite*
Kingdom	**:**	*Animalia*
Phylum	**:**	*Arthropoda*
Class	**:**	*Insecta*
Order	**:**	*Blattodea*
Family	**:**	*Rhinotermitidae*
Genus	**:**	*Coptotermes*
Species	**:**	*C. gestroi*

Figure 4. The species of termites in the reactor.

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This type of termite has specialized roles in the colony, usually workers, soldiers, and alates/reproductive (Scheffrahn et al., 2003). The termites found in the reactor usually feed on wood, grass, and leaf litter. Termites are also referred to as ecosystem engineers because termites shape the environment in which they live, greatly influence soil parameters such as affecting the grain in the soil and the chemical composition of the soil, or water storage, and greatly influencing the distribution of animals and plants. Termite activity can also help recycle nutrients and can affect the physical condition of the soil. Precisely in the middle of a termite mound, the content of P, K, Ca, Mg and organic C is greater compared to the surrounding soil (Kaschuk et al., 2006).

Microorganisms Roles on Organic Fertilizers Quality

The main factors that affect the quality of organic fertilizers are its macro elements, such as nitrogen (N), carbon (C), phosphorus (P_2O_5), C: N ratio (the result of the division between C-organic and nitrogen), and the element potassium (K) (National Standardization Agency, 2004).

Table 5. Test results of macroelements on the same sample.

Macroelements	Value (%)		
	Day-28	**Day-42**	**Day-56**
Phospor (P)	0,112	0,148	0,194
Potassium (K)	0,141	0,135	0,129
C-organic	3,58	3,37	3,4
Nitrogen (N)	0,54	0,46	0,44
C:N	6,63	7,32	7,73

Based on the results shows in Table 5, the value of P correlates with the number of microbial colonies shown in Table 4. This is because, in the recycling P process, bacteria that capable of processing P are required to increase the yield of bioavailable phosphorus (readily available phosphorus for organisms). Phosphate will form organic phosphate which comes from plant remains that were consumed by animals and fall back to the ground. Over time, organic phosphate will slowly form inorganic phosphate, in a process called mineralization, and this is caused by microorganisms that capable of breaking down organic matter (Lamb et al., 2014). The result also shows that potassium has the highest amount compared to others. Potassium is used by microorganisms to synthesize protein inside their cells, therefore the Potassium value in Table 5 is inversely proportional to the MPN value of bacteria in Table 4. It is one of the reasons why the recommended SNI value of MPN cannot exceed 1000 MPN/gr. Apart from the P and K elements, the loss of nitrogen as shown in Table 5 could be caused by the immobilization of soil nitrogen. Immobilization occurs when ammonium-N/nitrate-N in the soil is utilized by bacteria to make protein (Lamb et al., 2014).

CONCLUSION

Based on the results, it can be concluded that: 1) The rate of waste piles' height reduction was 2.18 cm/day for dry banyan leaves and 1.0 cm/day for dry bamboo leaves. When compared to L. rubellus and E. foetida worms, the level of decomposition efficiency of jasmine worms is low. 2) The total MPN value in the vermicompost sample met the quality standards, which is not more than 1000 MPN/g with the values of 290 and 460 MPN/g, respectively. 3) The dominant types of macroorganisms in earthworm composter media are the insect colonies of Asian Needle Ants (*Pachycondyla chinensis*) and Asian Subterranean Termites (*Coptotermes gestroi*). These types of macroorganisms are known to affect the nutrient quality of compost. 4) The relationship of P nutrients is directly proportional to the addition of MPN value. Meanwhile, the value of N and K nutrients decreased with the addition of MPN values, as well as the values of C and N nutrients.

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